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Lithology rules badland distribution and typology in a montane Mediterranean environment (upper Llobregat basin, Catalan Pre-Pyrenees)

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Badlands (i.e. highly dissected areas carved in soft bedrock with little or no vegetation) are pervasive in a wide range of environmental conditions across the Mediterranean region, including semiarid, sub-humid and humid environments, and represent hotspots of erosion and sediment production at the regional scale. On montane (cold sub-humid and humid) Mediterranean landscapes, harsh thermal conditions on north-facing slopes favors intense bedrock weathering and impose serious constraints for plant colonization, which has generally been argued to explain preferential distribution of badlands on shady aspects. We study the distribution and typology of badlands in the upper Llobregat basin (500 km2, 700-2400 m.a.s.l. elevation, 700-900 mm annual rainfall, 8-11ºC mean temp.). We mapped regional badlands by manually digitizing affected areas on recent (2012) high resolution (50 cm pixel) ortophotos. Badlands extend over about 200 ha in the upper Llobregat basin and are developed on Paleocene continental lutites (Garumnian Facies, Tremp Formation) and Eocene marine marls (Sagnari, Armancies and Vallfogona Formations). While badlands on Eocene marls showed a preferential distribution on north-facing shady slopes, badland occurrence on the highly unstable smectite-rich Garumnian lutites did not reveal clear aspect trends. In addition, elevation, which broadly controls winter temperatures in the region, did not show a clear influence on badland distribution. A principal component analysis was applied to study badland type using general geomorphological and vegetation metrics (i.e. badland size, slope, aspect, elevation gradient, connection to the regional drainage network, vegetation greenness) derived from a high resolution digital elevation model (5 m pixel) and pan-sharpened Landsat 8 MSAVI imagery (15 m pixel). Lithology was found to largely impact badland type, with Garumnian lutite badlands showing lower slope gradients (20º-30º average slope) than badlands on Eocene marls (30º-40º avg. slope). Badland size affected the extent to which badlands are hydrologically arranged in the basin (i.e. the larger the size and elevation gradient of the badland, the better connected was to the regional drainage network), while aspect regulated vegetation development (i.e. north-exposed badlands showed lower levels of vegetation greenness than south-exposed badlands). Overall our results reveal lithology as the main factor that broadly rule badland distribution and diversity under the montane Mediterranean conditions of the upper Llobregat basin, improving former results obtained in the area.

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